Physicochemical Characterization of Licuri Almond (*Syagrus coronata*) as Raw Material for Biodiesel Production

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Licuri (*Syagrus coronata*) is a palm tree native to the Brazilian semiarid region. Its kernels have a high oil content, making them a potential raw material for biodiesel production. This study aims to characterize the kernel through analyses of moisture, ash, volatile matter, and fixed carbon, discussing the feasibility of its use in biodiesel production. The discussion includes a comparison of the viscosity of licuri oil with other vegetable oils before and after transesterification, based on previous studies. The results suggest that licuri has properties compatible with established oilseeds, with advantages associated with oxidative stability and potential for regional use.

Keywords: Licuri. Biodiesel. Oilseeds. Physicochemical Properties.

The search for renewable energy sources has driven studies on the use of native oilseeds in biodiesel production. Licuri (*Syagrus coronata*), abundant in the semiarid Northeast region, stands out for its high oil content and potential to generate positive socioeconomic impacts in the region, according to studies by Santos and colleagues (2011) [1] and Agron Food Academy (2021) [2]. Furthermore, the fatty acid composition of licuri oil, rich in lauric acid and other saturates, gives biodiesel high oxidative stability, according to Silva and colleagues (2018) [3]. The same authors present that licuri oil is rich in saturated fatty acids, namely: lauric acid (42.6% to 44.6%), myristic acid (13.2% to 14.8%), palmitic acid (6.5% to 7.1%), caprylic acid (9.06% to 11.6%) and capric acid (6.03% to 6.7%). On the other hand, unsaturated fatty acids are present in smaller quantities, with emphasis on oleic acid (10.9% to 13.1%) and linoleic acid (1.0% to 2.5%).

Transesterification, according to Santos and colleagues (2011) [1], is the reaction between triglycerides and an alcohol (methanol or ethanol) in the presence of a catalyst, resulting in esters (biodiesel) and glycerol. Methanol has advantages such as greater reactivity, lower cost, and shorter reaction time, but it is a toxic alcohol of fossil origin. Ethanol, on the other hand, is renewable, less toxic, and can be produced locally, although it has disadvantages such as lower reactivity and the need for a greater excess of alcohol, higher temperature, and higher reaction time. It is also hygroscopic, which can lead to emulsion formation and saponification.

Biodiesel performance depends on several characteristics, such as cetane index, oxidative stability, pour point, and viscosity. Oils with a high content of saturated fatty acids, such as licuri, provide greater thermal and oxidative stability, reducing the formation of deposits in the engine, according to Silva and colleagues (2007) [4]. Licuri biodiesel, in turn, has excellent fluidity and efficient combustion, comparable to palm oil.

Material and Methods

The licuri almonds were subjected to laboratory analyses to determine moisture, volatile matter, ash, and fixed carbon. Fixed carbon was calculated by subtracting the percentages of moisture, volatile matter, and ash from 100%.

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The following methods, which were utilized in this study, are described below in a step-by-step format for replicability.

Ash Content

The ash content was determined by subjecting a known mass of the sample to combustion in a muffle furnace. The procedure followed was based on a standard gravimetric method:

1. A clean, pre-weighed porcelain crucible was placed in an oven at 105 °C for 30 minutes, then transferred to a desiccator to cool for 30 minutes.
2. The crucible was weighed and the mass (mass of crucible) was recorded.
3. Approximately 1 to 2 grams of the licuri almond sample were placed in the crucible.
4. The crucible with the sample was weighed and the mass (mcrucible+sample) was recorded.
5. The crucible was placed on a hot plate to slowly incinerate the sample until the smoke ceased.
6. The crucible was then transferred to a muffle furnace and heated at 550 °C for 2 hours.
7. After heating, the crucible was cooled in the desiccator for 30 minutes and weighed again.
8. This heating, cooling, and weighing process was repeated until a constant mass (constant mass) was achieved.
9. The ash content was calculated using the formula:

Ashes (%) = (mcrucible + sample − mcrucible) (constant mass − mcrucible)×100

Volatile Matter

The volatile matter was determined based on the mass loss after heating the sample to a high temperature under controlled conditions.

1. A clean, pre-weighed porcelain crucible with a lid was placed in an oven at 105 °C for 30 minutes, then transferred to a desiccator to cool for 30 minutes.
2. The crucible and lid were weighed and the mass (mcrucible+lid) was recorded.
3. Approximately 1 to 2 grams of the licuri almond sample were placed in the crucible.
4. The crucible with the sample and lid was weighed and the mass (mcrucible+lid+sample) was recorded.
5. The crucible was placed in a muffle furnace preheated to 950 °C for exactly 7 minutes.
6. After heating, the crucible was cooled in a desiccator for 30 minutes and weighed again.
7. The volatile matter was calculated using the formula:

Volatile (%)=(mcrucible + lid + sample − mcrucible + lid) [(mcrucible + lid + sample) − (crucible+lid+final sample)]×100

Moisture Content

The moisture content of the sample was determined by thermogravimetric analysis using a BEL moisture analyzer (moisture balance). For the procedure, an initial mass of 5.0771 g of the sample was evenly placed on a weighing pan. The equipment, which uses a halogen lamp for heating, initiated an automatic drying cycle, monitoring the mass loss in real time until a constant weight was reached.

Fixed Carbon

The fixed carbon content was determined by difference, using the following formula:

Fixed Carbon (%) = 100% − (Moisture (%) + Volatile Matter (%) + Ash (%))

Results and Discussion

Table 1 presents the average results obtained for the physical-chemical analyses of licuri almonds.

The results obtained from the physical-chemical analysis of licuri almonds (Table 1) reveal important characteristics for their application in biodiesel production. The ash analysis showed an average value of 1.90%. This

Table 1. Average results obtained for licuri almonds.

Parameter	Average Value
Moisture (%)	3.38
Ash (%)	1.90
Volatile Matter (%)	53.15
Fixed Carbon (%)	41.57

low inorganic residue content is a highly positive aspect, since excessive ash can cause problems in combustion equipment. Volatile matter, in turn, showed an average value of 53.15%, indicating a significant amount of compounds that can be released during combustion and contribute to the biomass's energy potential. Fixed carbon, calculated at 41.57%, represents the almond's calorific potential, the energy that can be extracted through combustion. The low moisture content of 3.38% in the licuri sample is a very positive result for biodiesel production. This is important because excess moisture can impair the process, causing soap formation and consuming the catalyst (KOH), which is essential for the reaction. With low moisture, biodiesel production tends to be more efficient.

Table 2 shows the comparison of the viscosity of licuri oil with other vegetable oils before and after transesterification.

As shown in Table 2, licuri oil has an initial viscosity of 8.5-12.0 mm²/s, which is lower than that of other oils such as soybean and sunflower. However, the viscosity reduction after transesterification is significant, approaching the values required by the National Petroleum Agency (ANP) specifications for biodiesel. This characteristic indicates good conversion and compliance with standards, in addition to confirming licuri's potential as a feedstock.

Conclusion

The results indicate that licuri almonds exhibit characteristics consistent with other oilseeds used in biodiesel production, notably low moisture content and good chemical composition. Comparative viscosity analysis reinforces their technical potential, especially considering the oil's oxidative stability. Future studies should include experimental biodiesel production and its complete characterization. Process optimization, considering appropriate parameters, can make licuri biodiesel a sustainable and economically viable alternative, contributing to the diversification of the energy matrix, especially in regions where the raw material is abundant.

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Table 2. Viscosity of oils before and after transesterification.

Oil	Oil Viscosity (mm²/s at 40°C)	Biodiesel Viscosity (mm²/s at 40 °C)	References
Licuri	8.5-12.0	3.8-4.5	Silva and colleagues, 2018 [3]
Soy	30-35	4.0-4.5	Guimarães, 2019 [5]
Palm	35-40	4.5-5.5	Lima and colleagues, 2012 [6]
Sunflower	30-40	4.0-5.0	Silva and colleagues, 2007 [4]
Canola	30-35	4.1-4.6	Lima and colleagues, 2012 [6]
Corn	32-37	4.2-4.8	Silva and colleagues, 2007 [4]
Cotton	45-55	4.5-5.2	Lima and colleagues, 2012 [6]

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